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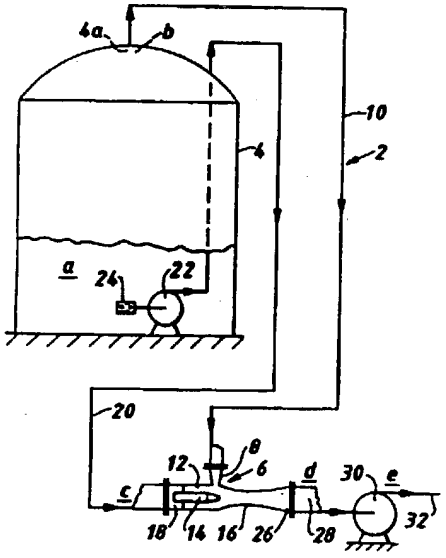
(54) Abstract Title
A method of returning boil off gas from stored cryogenic liquified gas to its liquid phase

(57) An installation 2 for the storage and supply of a cryogenic liquefied gas, for example liquefied natural gas, comprises storage tank 4 for the liquefied gas at low temperature having an upper internal region 4a in which the boil off gas collects. That boil off gas is supplied by pipe 10 to an inlet 8 of a liquid jet pump or liquid jet compressor 6. Liquefied gas is conveyed from the tank 4 by pump 22 and pipe 20 to a jet 14 of the jet compressor 6. The boil off gas is entrained by the cold liquefied gas leaving the jet 14 in a venturi 16 to form a stream, the pressure of which is higher than that of the supply pressure of the vaporised gas so that the gas resumes its liquid phase, and the liquefied gas is raised to high pressure by high pressure pump 30 for onward supply.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

This print takes account of replacement documents submitted after the date of filing to enable the application to comply with the formal requirements of the Patents Rules 1995

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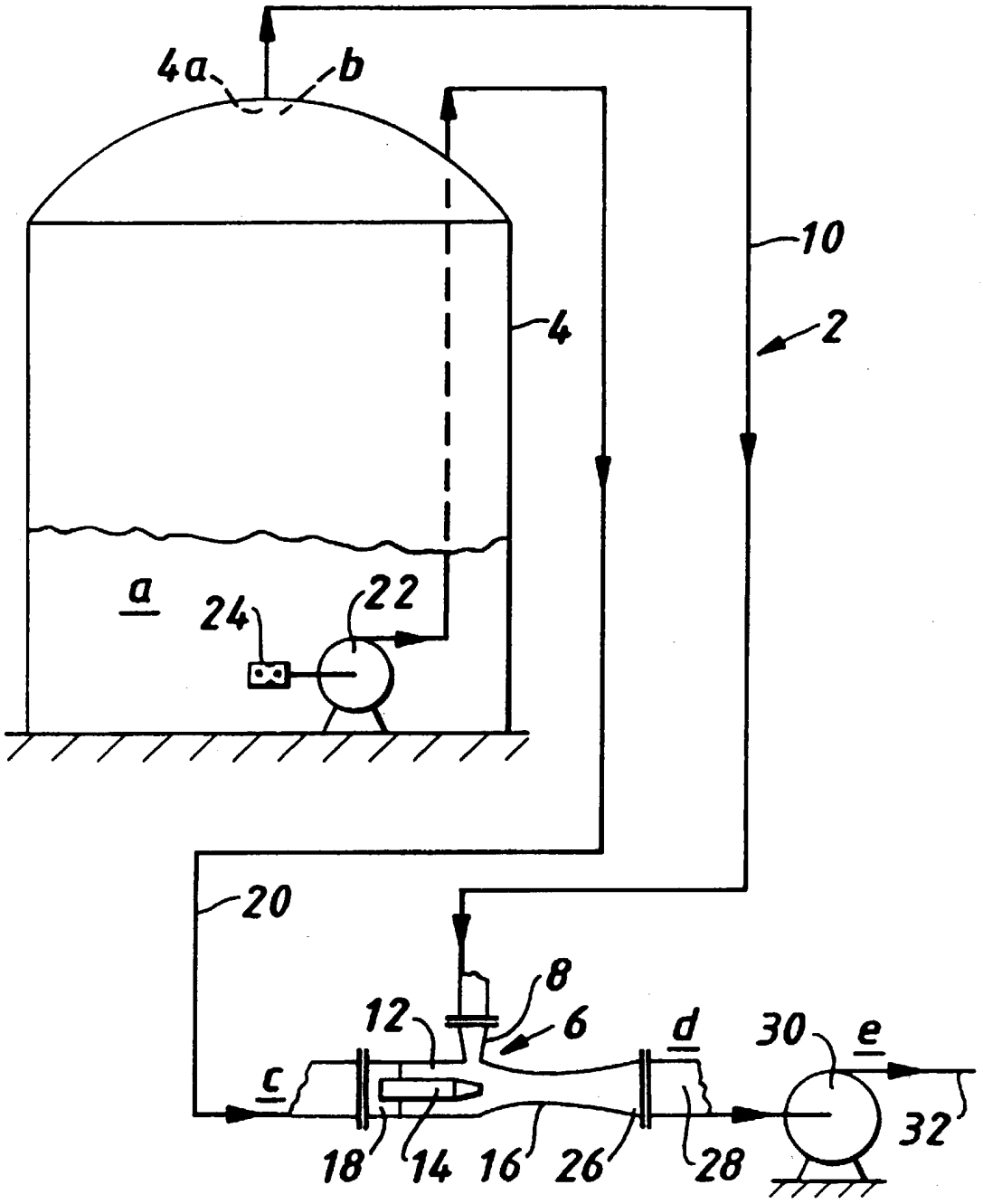
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A Method of and Apparatus for Returning A Vaporised Gas to Its Liquid Phase

This invention relates to a method of and apparatus for returning a vapourised gas and particularly a boil off gas to its liquid phase.

In installations for the storage and supply of liquified natural gas (LNG), some of the LNG in a storage tank boils off and collects as boil off gas in the upper part of the tank. A pump extracting LNG from the tank sends the pumped LNG to an absorber. The boil off gas is supplied to a reciprocating compressor which compresses the boil off gas and supplies it at suitable pressure to the absorber to produce an equilibrium mixture of LNG and boil off gas all in the liquid phase.

Reciprocating compressors are relatively expensive and it is an object of the present invention to provide a method of and apparatus for returning a boil off gas to the liquid phase which is cheaper than using a reciprocating compressor.

According to a first aspect of the invention there is provided a method of returning a vaporised gas to its liquid phase, the method comprising forming at least one stream of liquefied gas from a supply of liquefied gas, supplying the vaporised gas at a supply pressure to the or each stream, entraining the vaporised gas in the or each stream so that a mixed stream of liquefied gas and entrained vaporised gas is formed and causing the pressure of the or each mixed stream to increase beyond that of the supply pressure of the vaporised gas so that the entrained vaporised gas returns to its liquid phase.

According to a second aspect of the present invention, there is provided apparatus for returning a vaporised gas to its liquid phase, the apparatus comprising means for forming at least one stream of liquefied gas from a supply of liquefied gas, means for supplying the vaporised gas at a supply pressure to the or each stream, means for entraining the vaporised gas in the or each stream so that a mixed stream or streams of liquefied gas is or are formed and means for causing the pressure of the mixed stream or streams to increase beyond that of the supply pressure of the vaporised gas so that the entrained vaporised gas returns to its liquid phase.

Each aspect of the invention will now be further described, by way of example with reference to the accompanying drawing in which an installation formed according to the second aspect of the invention is shown diagrammatically, and partly in section, in which the method according to the first aspect of the invention can be performed.

With reference to the drawing, an installation is shown at 2 for storing and supplying which in this case is cryogenic liquefied gas.

That gas may be liquefied fuel gas, for example liquefied natural gas (LNG). The installation 2 includes a heat insulated storage vessel or storage tank 4 to contain the cryogenic liquefied gas at low temperature eg - 160°C and at a pressure a which may be substantially atmospheric pressure or substantially 1.0 bar. The upper part of the tank 4 provides an internal region 4a in which boil off gas from the liquefied gas in the lower part of the tank can collect. The pressure of the boil off gas in region 4a is b which is equal to pressure a. A liquid jet pump or liquid jet compressor 6 is provided and has a low

pressure inlet 8 connected to the region 4a by a pipe 10. The inlet 8 opens into a side of a chamber 12 containing at least one nozzle or jet 14 facing towards a venturi passage 16. An inlet 18 of the jet compressor 6 supplies the jet 14 with liquefied gas at low temperature, the liquefied gas being supplied to the inlet 18 by a pipe 20 receiving the output from a pump 22 which has an inlet 24 in the tank 4. The pump 22 delivers liquefied gas at a pressure c which is greater than pressure a or pressure b. Liquefied fuel gas issuing at low temperature from the jet 14 as a stream entrains therein boil off gas drawn from the region 4a to the chamber 12 via the inlet 8 to form a mixed stream of the liquefied gas and the boil off gas. As a result of passage through the chamber 12 and the venturi passage 16 the entrained boil off gas resumes its liquid phase in the cold liquefied gas which has issued as a stream from the jet 14. Now the liquefied gas at low temperature is output, from an outlet 26, at a pressure d to a pipe 28 leading to another pump 30 which may be a high pressure pump raising the pressure of the liquefied gas output in output pipe 32 to a pressure e for onward supply. Output pressure d from the jet compressor 6 may be less than the input pressure c, and pressure e output from the pump 30 may be greater than pressure c. The temperature of the boil off gas and that of the liquefied gas pumped through the system from pump inlet 24 to pump outlet pipe 32 may be substantially the same as that of the liquefied gas in the tank 4.

If the liquefied gas in the tank 4 is LNG its temperature may be substantially -160°C which is also substantially the temperature of the boil off gas. The pressure a and b of the LNG in the tank 4 may be substantially 1.1 bar. Output pressure c of the pump 22 may be in the range of substantially 3.0 to substantially 7.0 bar, say substantially 7.0 bar, and the

temperature of the LNG supplied to the inlet 18 of the jet compressor 16 may, as indicated above, be substantially -160° C. Output pressure d from the jet compressor 16 may be substantially 2.0 bar, and the output pressure e of LNG from the pump 30 may be in the range substantially 70 to substantially 80 bar.

While not shown it will be appreciated that there may be more than one storage vessel containing liquefied and boil off gas and each storage vessel may supply liquefied and boil off gas to a single jet or nozzle serving all the vessels via a pump which may also serve all the vessels or each vessel may be provided with its own individual pump for supplying the gases to the single jet or nozzle.

Alternatively each vessel could be provided with its own individual jet or nozzle and its own individual pump for each nozzle.

In addition the liquefied gas and the boil off gas may be derived from different vessels or sources and indeed the liquefied gas may even be a different gas to the boil off gas though still physically compatible therewith.

Claims

1. A method of returning a vaporised gas to its liquid phase, the method comprising forming at least one stream of liquefied gas from a supply of liquefied gas, supplying the vaporised gas at a supply pressure to the or each stream, entraining the vaporised gas in the or each stream so that a mixed stream of liquefied gas and entrained vaporised gas is formed and causing the pressure of the or each mixed stream to increase beyond that of the supply pressure of the vaporised gas so that the entrained vaporised gas returns to its liquid phase.

2. A method as claimed in claim 1 in which the stream or streams of liquefied gas is or are formed by passing the liquefied gas through at least one nozzle or jet.

3. A method as claimed in claim 1 or claim 2 in which the liquefied gas is supplied from at least one storage vessel and the vaporised gas also issues from a region within the same vessel or vessels.

4. A method as claimed in claim 3 in which the liquefied gas from the or each storage vessel is supplied at a first pressure and the vaporised gas in the region of the or each storage vessel is supplied at a second pressure which is lower than the first pressure.

5. A method as claimed in claim 4 in which the liquefied gas stream or streams is or are at a third pressure which is greater than the second pressure.

6. A method as claimed in any of the preceding claims in which the vaporised gas is boil off gas from a liquefied gas.

7. A method as claimed in any of the preceding claims in which the liquefied and vaporised gas is natural gas.

8. Apparatus for returning a vaporised gas to its liquid phase, the apparatus comprising means for forming at least one stream of liquefied gas from a supply of liquefied gas, means for supplying the vaporised gas at a supply pressure to the or each stream, means for entraining the vaporised gas in the or each stream so that a mixed stream or streams of liquefied gas is or are formed and means for causing the pressure of the mixed stream or streams to increase beyond that of the supply pressure of the vaporised gas so that the entrained vaporised gas returns to its liquid phase.

9. Apparatus as claimed in claim 8 in which the means for forming the or each stream of liquefied gas comprises at least one jet or nozzle.

10. Apparatus as claimed in claim 8 or claim 9 in which at least one storage vessel is provided from which the liquefied gas and the vaporised gas is supplied.

11. Apparatus as claimed in any of claims 8 to 10 in which the means for entraining the vaporised gas in the or each stream comprises a chamber for the or each stream, which chamber receives separately a stream of liquefied gas and a supply of vaporised gas to form a mixed stream of the liquefied gas and the vaporised gas.

12. Apparatus as claimed in any of claims 8 to 11 in which the means for causing the pressure of the or each mixed stream to increase beyond that of the supply pressure of the vaporised gas comprises a venturi.

13. A method of returning a vapourised gas to its liquid phase substantially as hereinbefore described with reference to the accompanying drawing.

14. Apparatus for returning a vapourised gas to its liquid phase substantially as hereinbefore described with reference to the accompanying drawing.